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Butterfly-flower interactions in Coringa Mangrove Forest, Andhra Pradesh, India

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ABSTRACT

In Coringa mangrove forest, 24 butterflies belonging to Papilionidae, Pieridae, Nymphalidae, Lycaenida and Hesperiidae were recorded on 10 plant species *Avicennia alba*, *A. officinalis* (crypto-viviparous), *Lumnitzera racemosa* (non-viviparous true mangrove), *Excoecaria agallocha, Caesalpinia crista, Mukia maderaspatana, Malachra capitata, Clerodendrum inerme, Suaeda maritima* and *S. nudiflora* (oviparous mangrove associates) located in limnatic, oligohaline and mesohaline zones. Among butterflies, the nymphalids, *Danaus chrysippus* and *D. genutia,* and the lycaenid, *Euchrysops cnejus* collected sap from the leaves of *Suaeda* spp. and nectar from the flowers of other plant species. All other butterflies collected only nectar from the flowers which they visited. The butterflies never visited the flowers of plant species located in polyhaline and euhaline zones and the absence of their foraging activity in these zones is attributed to the presence of high wind conditions most of the time which are not favorable for their flying. Therefore, the mangrove plants located in the areas from limnatic to mesohaline zone are important as nectar sources for adult butterflies and hence such plants need to be allowed for their continued existence in order to provide nectar for the visiting butterfly species as well as to extend their ecological service to prevent soil erosion and land build up and stabilization.

Key words: Butterflies, mangrove plants, nectar, leaf sap, salinity zones.

1. INTRODUCTION

Sexual reproduction in mangrove taxa is linked to flower-visiting insects that effect pollination while foraging for the floral rewards. The sexual systems in mangrove plants include hermaphroditism, monoecy and dioecy. Monoecy is reported only in *Xylocarpus* species and dioecy only in *Excoecaria agallocha*; both are obligately vector-dependent. Hermaphroditism with mixed mating system is reported in all other mangrove plants. In hermaphroditic species, *Bruguiera* species and *Ceriops tagal* are obligately vector-dependent while all other plants with the ability for self-pollination by autogamy are largely vector-dependent. The flowers are nectariferous in all mangrove plants, except *Rhizophora* spp. in which the flowers are nectarless. Among flower-visiting insects, bees have been reported to be very important pollinators of mangrove plants (Solomon Raju, 2013; 2020; Solomon Raju and Henry, 2008; Solomon Raju and Rajesh, 2014; Solomon Raju et al. 2008; 2012; 2014; 2019). Accordingly, workers across the globe

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have concentrated mainly on bee-flower interactions in mangrove plants from pollination perspective. Little information is available on other flower-visiting insects, especially butterflies, and their role in the pollination of mangrove plants. Further, there are absolutely no studies on butterfly-flower interactions in mangrove forests, even from ecosystem perspective. Therefore, the present study is an attempt to provide information on butterfly interactions with mangrove plants and the benefit derived by each partner from this interaction. It is the first report on butterfly-mangrove plant interactions or relationships and it forms the basis for further studies in this direction.

2. MATERIALS AND METHODS

The State of Andhra Pradesh, India has several mangrove forest pockets of which the Coringa Mangrove Forest (16°30′-17°00′N and 82°10′-80°23′E) in East Godavari district was used for the study during April 2019-May 2021. Based on the flowering period of individual mangrove plant species, field observations were made to record the plant species visited by butterflies. The butterfly species visiting each plant species were identified and sorted out family-wise. The butterflies were also observed for their ability to access the nectar and effect pollination in the flower-probing process. The field observations on the foraging activity of butterflies visiting individual plant species have been described and discussed from ecosystem perspective.

3. RESULTS AND DISCUSSION

In Coringa mangrove forest, a total of 24 butterflies were recorded on the flowers of different plant species. Of these, 3 species belonged to Papilionidae, 4 species to Pieridae, 13 species to Nymphalidae and 2 species each to Lycaenidae and Hesperiidae. The papilionids included *Papilio aristolochiae* (Figure 4a), *P. demoleus* (Figure 1c, Figure 3a,b) and *P. hector* (Figure 2a). The pierids included *Catopsilia pomona* (Figure 1d, Figure 2b), *C. pyranthe* (Figure 1e, Figure 3c), *Eurema hecabe* (Figure 2n, Figure 3d) and *Pareronia valeria* (Figure 4d). The Nymphalids included *Acrae violae* (Figure 2h), *Ariadne ariadne* (Figure 3g), *Cynthia cardui* (Figure 2m), *Danaus chrysippus* (Figure 1a,l, Figure 2f, Figure 3f,h, Figure 4k), *Danaus genutia* (Figure 1m, Figure 2o, Figure 3e, Figure 4e,g,i,l), *Euploea core* (Figure 1n, Figure 2g,p, Figure 4b), *Hypolimnas misippus* (Figure 1i, Figure 2c), *H. bolina* (Figure 2d,k), *Junonia lemonias* (Figure 1f, Figure 2j), *J. hierta* (Figure 1g), *J. almana* (Figure 1h, Figure 2i), *Tirumala limniace* (Figure 1j,k, Figure 2l) and *T. septentrionis* (Figure 2e). Lycaenids included *Eychrysops cnejus* (Figure q, Figure 3h, Figure 4l) and *Everes lacturnus* (Figure 1b). The hesperiids included *Borbo cinnara* (Figure 2s, Figure 3i, Figure 4c,f) and *Hasora chromus* (Figure 2r). Individual butterfly species visiting the plant species during day time for nectar from flowers and/or sap from leaves is listed in Table 1. Butterflies were found to visit only 3 true mangrove species and 7 mangrove associate species. True mangroves included 2 crypto-viviparous species, *Avicennia alba, A. officinalis* and 1 non-viviparous species, *Lumnitzera racemosa.* The mangrove associates included *Excoecaria agallocha, Caesalpinia crista, Mukia maderaspatana, Malachra capitata, Clerodendrum inerme, Suaeda maritima* and *S. nudiflora*. The flowers are white in *L. racemosa* and *C. inerme* while they are yellow or light yellow in all other plant species. The nectar produced by individual flowers varied from traces to minute volume; it is exposed and easily accessible for butterflies in *Avicennia* spp., *E. agallocha, M. maderaspatana* and *M. capitata* while it is deeply concealed and not easily accessible for butterflies in *L. racemosa, C. crista* and *C. interme*. Butterflies visited *Suaeda* spp. for collecting sap from leaves before flowering and after fruiting but not for floral nectar. They visited the flowers of all other plant species for nectar collection. They were active at the flowers collecting nectar throughout the day with intense activity during late forenoon to early afternoon period. In *C. crista*, the posterior banner-like petal of the corolla with reddish nectar guide facilitates the butterfly to probe the flower in right direction to access the nectar. In all these plant species except *Suaeda* spp., the butterflies while probing the flower effect pollination but they have been reported to be either supplementary pollinators or minor pollinators in *Avicennia* spp. (Solomon Raju et al. 2012), *L. racemosa* (Solomon Raju et al. 2014) and *E. agallocha* (Henry and Solomon Raju, 2018). It is reported that *Suaeda maritima, S. monoica* and *S. nudiflora* contain alkaloids, triterpenoids, sterols and various other chemical compounds (Al-Mohammadi et al. 2005; Suganthy et al. 2009; Gurudeeban et al. 2011). In the present study, the leaf sap collection from *Suaeda* spp. by butterflies indicates that these species are the source for these alkaloids which are important for them for protection against their predators (Solomon Raju and Rajendra Kumar, 2016).

The distribution pattern of the plant species utilized butterflies in this forest indicates that *C. crista, M. maderaspatana, M. capitata, C. inerme, S. maritima* and *S. nudiflora* are confined to limnatic and/or oligohaline zone while *Avicennia* spp., *L. racemosa* and *E. agallocha* are distributed in oligohaline and mesohaline zones. The study indicates that butterflies utilize the mangrove plant species that occur in limnatic, oligohaline and mesohaline zones only since too windy locations of polyhaline and euhaline zones are not favorable for their flying but these zones are potential floral nectar sources. Therefore, mangrove plants located from landward to mesohaline zones are important nectar sources for butterflies while *Suaeda* spp. growing in the limnatic and inland areas are important as alkaloid sources.

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Figure 1. ***Avicennia alba***: a. Nymphalid, *Danaus chrysippus*, b. Lycaenid, *Everes lacturnus*, ***Avicennia officinalis***: c. Papilionid, *Papilio demoleus*, d. & e. Pierids – d. *Catopsilia pomona*, e. *Catopsilia pyranthe*, f-n: Nymphalids – f. *Junonia lemonias*, g. *Junonia hierta*, h. *Junonia almana*, i. *Hypolimnas misippus*, j. & k. *Tirumala limniace*, l. *Danaus chrysippus*, m. *Danaus genutia*, n. *Euploea core*.

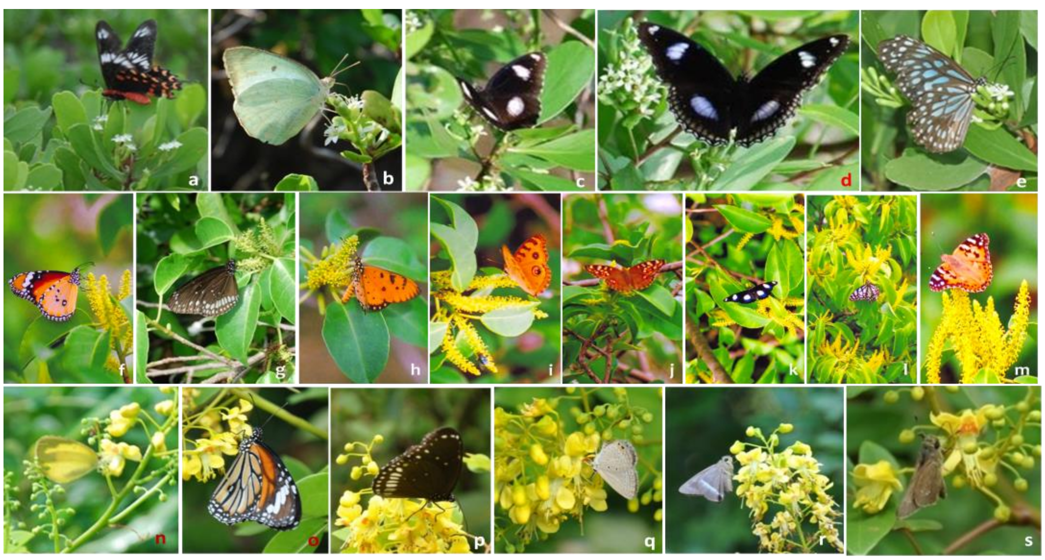

Figure 2. ***Lumnitzera racemosa***: a. Papilionid, *Pachliopta hector*, b. Pierid, *Catopsilia pomona*, c-e. Nymphalids – c. *Hypolimnas misippus*, d. *Hypolimnas bolina*, e. *Tirumala septentrionis*, f-m: ***Excoecaria agalloca*** – nymphalids f. *Danaus chrysippus*, g. *Euploea core*, h. *Acrae violae*, i. *Junonia almana*, j. *Junonia lemonias*, k. *Hypolimnas bolina*, l. *Tirumala limniace*, m. *Cynthia cardui*, ***Caesalpinia crista***: n. Pierid, *Eurema hecabe*, o. & p. Nymphalids – o. *Danaus genutia*, p. *Euploea core*, q. Lycaenid, *Euchrysops cnejus*, r. & s. Hesperiids – r. *Hasora chromus*, s. *Borbo cinnara*.

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Table 1. List of butterflies visiting the flowers/leaves of mangrove plant species at Coringa Mangrove Forest

Family	Species	*Avicennia alba*	*Avicennia officinalis*	*Lumnitzera racemosa*	*Excoecaria agallocha*	*Caesalpinia crista*	*Mukia maderaspatana*	*Malachra capitata*	*Clerodendrum inerme*	*Suaeda maritima**	*Suaeda nudiflora**
Papilionidae	*Papilio aristolochiae*	-	-	-	-	-	-	+	-	-	-
	Papilio demoleus	-	-	-	-	-	+	-	-	-	-
	Pachliopta hector	-	-	+	-	-	-	-	-	-	-
Pieridae	*Catopsilia pomona*	-	+	+	-	-	-	-	-	-	-
	Catopsilia pyranthe	-	+	-	-	-	+	-	-	-	-
	Eurema hecabe	-	-	-	-	+	+	-	-	-	-
	Pareronia valeria	-	-	-	-	-	-	-	+	-	-
Nymphalidae	*Acrae violae*	-	-	-	+	-	-	-	-	-	-
	Ariadne ariadne	-	-	-	-	-	+	-	-	-	-
	Cynthia cardui	-	-	-	+	-	-	-	-	-	-
	Danaus chrysippus	+	+	-	+	-	+	-	-	+	+
	Danaus genutia	-	+	-	-	+	+	-	+	+	+
	Euploea core	-	+	-	+	+	-	+	-	-	-
	Hypolimnas misippus	-	+	+	-	-	-	-	-	-	-
	Hypolimnas bolina	-		+	+	-	-	-	-	-	-
	Junonia lemonias	-	+	-	+	-	-	-	-	-	-
	Junonia hierta	-	+	-	-	-	-	-	-	-	-
	Junonia almana	-	+	-	+	-	-	-	-	-	-
	Tirumala limniace	-	+	-	+	-	-	-	-	-	-
	Tirumala septentrionis	-	-	+	-	-	-	-	-	-	-
Lycaenidae	*Euchrysops cnejus*	-	-	-	-	+	+	-	-	-	+
	Everes lacturnus	+	-	-	-	-	-	-	-	-	-
Hesperiidae	*Borbo cinnara*	-	-	-	-	+	+	+	+	-	-
	Hasora chromus	-	-	-	-	+	-	-	-	-	-
		2 species	10 species	5 species	8 species	6 species	8 species	3 species	3 species	2 species	3 species

*Butterflies sucking sap from leaves but not collecting nectar from flowers

“+” indicates butterflies visiting the flowers; “*” indicates butterflies not visiting the flowers

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Figure 3. ***Mukia maderaspatana****:* a. & b. Papilionid*, Papilio demoleus*, c. & d. Pierids – c. *Catopsilia pyranthe*, d. *Eurema hecabe,* e-g. Nymphalids – e. *Danaus genutia*, f. *Danaus chrysippus*, g. *Ariadne ariadne*, h. Lycaenid, *Euchrysops cnejus*, i. Hesperiid, *Borbo cinnara.*

Figure 4. ***Malachra capitata***: a. Papilionid, *Pachliopta aristolochiae*, b. Nymphalid, *Euploea core*, c. Hesperiid, *Borbo cinnara*, ***Clerodendrum inerme****:* d. Pierid, *Pareronia valeria*, e. Nymphalid, *Danaus genutia*, f. Hesperiid, *Borbo cinnara,* ***Suaeda maritima****:* g. & h. Nymphalids – g. *Danaus genutia*, h. *Danaus chrysippus,* ***Suaeda nudiflora****:* i-l. Nymphalids– i & j. *Danaus genutia* sucking leaf sap, k. *Danaus chrysippus* sucking leaf sap, l. Lycaenid butterfly, *Euchrysops cnejus* sucking leaf sap.

4. CONCLUSIONS

In Coringa mangrove forest, 24 butterflies belonging to Papilionidae, Pieridae, Nymphalidae, Lycaenida and Hesperiidae were recorded on 10 plant species. Of these, the nymphalids, *Danaus chrysippus* and *D. genutia,* and the lycaenid, *Euchrysops cnejus* collected sap from the leaves of *Suaeda* spp. and nectar from the flowers of other plant species. All other butterflies collected only nectar from the flowers which they visited. All plant species visited by butterflies are located in limnatic, oligohaline and mesohaline zone only. In these zones, they visited 2 crypto-viviparous species (*Avicennia alba* and *A. officinalis),* 1 non-viviparous species (*Lumnitzera racemosa*) and 7 mangrove associates (*Excoecaria agallocha, Caesalpinia crista, Mukia maderaspatana, Malachra capitata, Clerodendrum inerme, Suaeda maritima* and *S. nudiflora*). The butterflies never visited the flowers of plant species located in polyhaline and euhaline zones and the absence of their foraging activity in these zones is attributed to the presence of high wind conditions most of the time which are not favorable for their flying. Therefore, the mangrove plants located in the areas from limnatic to mesohaline zone are important as nectar sources for adult butterflies and hence such plants need to be allowed for their

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continued existence in order to provide nectar for the visiting butterfly species as well as to extend their ecological service to prevent soil erosion and land build up and stabilization.

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Authors contributions:

Both authors contributed equally.

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Conflicts of interests

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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